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Cognitive Representations of Battlespace Complexity: Six Fundamental Variables of Combat

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Abstract

War is a complex phenomenon. The dynamics and complexities associated with modern military engagements, from peace keeping to major regional conflict, demand that the information associated with such environments be carefully selected, framed, and presented to facilitate effective decision making at all levels. We hypothesized that the six fundamental variables of combat represented by the military acronym METT-TC (Mission, Enemy, Troops, Terrain and weather, Time available, and Civilian considerations) would provide a framework from which to efficiently organize and represent the salient dimensions of the battlefield during the military decision-making process (MDMP). The U.S. Army's Crusader Concept Experimentation Program 3 (CEP 3) was selected as an ideal arena in which to conduct a preliminary investigation of METT-TC dimensions and their associations with representative battle command decisions. Subjects were five field grade officers permanently assigned to a U.S. Army combat unit. During a 2-week experiment period, 24 decisions were isolated and documented across three phases of combat operations (delay, defend, attack). Importantly, decision makers reported high levels of both "significance" and "understanding" for most of the dimensions represented by METT-TC, except for "civilian considerations," which were not represented in the experimental scenarios. Significant differences in levels of "understanding" according to decision types (major versus minor) were observed. In summary, experienced military decision makers recognize the importance of METT-TC dimensions, and we suggest that these dimensions offer a means to present aggregate information to increase situational understanding. Further research is recommended to isolate patterns of interactions among these important dimensions across the full spectrum of military operations.

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COGNITIVE REPRESENTATIONS OF BATTLESPACE COMPLEXITY:
SIX FUNDAMENTAL VARIABLES OF COMBAT

INTRODUCTION

"War is by nature confused, and the process of command complex" (Van Creveld, 1985).

The basic nature of combat and the demands of command in battle have not changed appreciably in the last 1000 years, and such factors as friction, chance, and uncertainty remain the basic contributors to "the fog of war" (Czerwinski, 1998). However, numerous factors and dimensions have changed the landscape of modern warfare and have increased the complexity of the environment. Such factors as globalization, rapid change, information technology (IT), increased weapons lethality, and the mass media have resulted in increased demands on combat leaders at all levels. These factors have become strong potential sources for increased stress in the absence of new resources to cope with the inevitable demands of the battlefield (Davis, 1977).

We live in an "open" age, characterized in part by rapid change, increased awareness, information and technological explosion, economic and social globalization, and a broad spectrum of national and international political influences and conflicts. Each of these factors can interact in complex ways to profoundly influence our perceptions of and actions in the world. It is becoming increasingly clear that all military situations and environments are sensitive to initial conditions and include uncertainties, nonlinearities, and discontinuities which have substantial implications for decision makers, planners, analysts, and modelers (Davis, 1997).

Throughout history, many exquisite military plans resulted in disaster because of a failure by commanders to effectively cope with the salient factors and their unforeseen and unexpected interactions (Cohen & Gooch, 1991). Modern military systems are made increasingly complex by the many human and technological elements involved. The sources of complexity include dimensional complexity (process and interactions on many levels), uncertainty and computational complexity (Cooper, 1994). Military organizations, if they are to effectively adapt to complex environments, must learn to cope with probabilistic rather than deterministic attributes and must recognize that elements at all levels and on all sides of a conflict will interact, learn, and modify their behavior over time.

The United States military is investigating the applications of such "new science" ideas as complexity, chaos, complex adaptive systems, and nonlinear and ecological paradigms in an effort to understand, comprehend, and cope with the demands associated with the variety of missions

anticipated in the 21st century (Czerwinski, 1998). In fact, such language is appearing in doctrinal publications and across the range of National Security and command, control, communications, computer, intelligence, surveillance and reconnaissance (C4ISR) communities (Alberts & Czerwinski, 1997; Alberts, 1999).

Indeed, the extreme environmental conditions (e.g., weather, terrain) and cognitive demands typically associated with combat require that digitized information systems be carefully designed to augment and support the military decision maker's ongoing cognitive efforts (Bourne, 1969). Such systems must be able to adapt in order to correct and maintain current representations of the important dimensions of the decision space, consistent with the decision maker's attempt to place stimuli into some kind of sensible framework (Weick, 1995). To fully appreciate and understand the magnitude of such implications, the forces impinging upon them, and their relationships to each other, we should attempt to put them within a heuristic framework (Basan, 1998; Hunt & Blair, 1985). Because of the multi-variate and dynamic nature of combat environments, we have begun to investigate applications of the emerging sciences of "complexity" and "complex adaptive systems." Specifically, we are exploring these approaches as a means to provide a unifying framework for designing, building, and operating knowledge systems for military decision makers, especially in combat environments where the demands on individuals, teams, and organizations are considerable.

This research was sponsored by the U.S. Army Research Laboratory's Science and Technology Objective (STO) Program entitled "Cognitive Engineering of the Digital Battlefield." The primary focus of the STO is battle command decision making in digital environments. For this investigation, we hypothesized that the dimensions represented by the military acronym METT-TC (**M**ission, **E**nemy, **T**roops, **T**errain and weather, **T**ime available, and **C**ivilian considerations) can provide a useful and valid framework from which to organize and represent the fundamental dimensions of complexity associated with combat environments and the military decision-making process (MDMP) (U.S. Army, 1992) and a useful framework to develop and maintain dominant battlespace knowledge (DBK) (Libicki & Johnson, 1996).

BACKGROUND

U.S. Army doctrine states that "...information products and their interpretation result in decisions and directives. Battle command involves acquiring and displaying this information. All units continually acquire information about the mission, enemy terrain and weather, troops available, and time (METT-T) through a variety of means" (U.S. Army, 1992). While some hold

to the idea that METT-T only applies as a framework during deliberate planning (estimate of the situation), we believe that such estimates are, in fact, continuous and constitute the vast majority of salient issues for decision makers at all levels of leadership during the execution of operations. In recent years, the dimensions represented by METT-T have been expanded to include the importance of civilian considerations (e.g., politics, culture, globalization, media, etc.), and recent service doctrine and joint publications are now using the term METT-TC.

Variables normally associated with each of the METT-TC dimensions are described in Table 1. We believe that these dimensions are of such fundamental importance that they can, for example, provide the foundation and framework of a dynamic, multi-agent visualization tool to provide DBK, support situational awareness and understanding, and improve the effectiveness of decision making during stress.

Military decision making is not merely a mathematical computation or a "cookbook" process. Effective decision making requires both the situational awareness to recognize the essence of a given problem and the creative ability to devise a practical solution (U.S. Marine Corps, 1997). The dynamics and complexities associated with modern military operations and decision making demand that the information associated with such dynamic environments be carefully selected, framed, and presented at the appropriate time to facilitate effective decision making. McMaster (1996) believes that information only becomes knowledge when it is integrated with an entire system in such a way that it is available for action at appropriate times and places.

Kahan, Worley, and Stasz (1989) conducted a review of "commander's information" and concluded that previous work in this area was characterized by serious shortcomings in the areas of conceptual and methodological limitations. Their descriptions are instructive and bear directly on the internal, external, and operational validity of the present research.

In the conceptual arena, four limitations were described:

1. *Lack of a conceptual framework* (i.e., decision-making and planning processes)

2. *The situational framework was not considered*

3. *Information needs not assessed from the commander's point of view*

4. *Assumptions that information needs can be generalized across commanders*

In the methodological arena, two limitations were described:

1. *Results were not corroborated*

Table 1

Salient Dimensions of Battlespace Complexity: METT-TC

Dimensions	Description	Essential elements
Mission	Primary task assigned to a unit.	Who, what, when, where, why
Enemy	Opposition or threat as defined. Should consider technology factors	Capabilities, likely courses of action (COAs) impact on own forces, positions, morale, reserves, tactics, etc.
Troops	Troop strength and combat status; in terms of the seven battlefield operating systems (BOSs) and human dimension factors (e.g., readiness, morale, etc.) The seven BOSs are Command and control Maneuver Fire support Intelligence Air defense Mobility, counter-mobility, survivability Combat service support Assessment of technology and equipment	Maneuver, fire support and engineer assets are usually the key elements considered, depending on the mission Technology and equipment in terms of Types Availability Functionality Reliability, maintainability, support
Terrain & weather	Military aspects of terrain and weather; when terrain affects friendly and enemy capabilities to shoot, move, and communicate. When weather affects equipment, trafficability, and soldiers	Essential factors represented by OCOKA: When 'O' = Observation and fields of fire 'C' = Cover and concealment 'O' = Obstacles and movement 'K' = Key terrain 'A' = Avenues of approach Weather conditions and predictions Effects on man-generated obscurants Drainage Effects on ingress and egress
Time	A critical factor in all operations	Coordination and planning Preparation and reconnaissance Movement considerations (all phases) Rate of closure of a moving enemy Timing and duration of preparatory fires Completion of specific actions Must account for effects of weather
Civilian considerations	Factors (own and others) not covered above, which could have an effect on the success of the mission	Politics, economics, and area stability Media Culture, subcultures, and power groups Ethics and morals Allies, coalition partners, neutrals Non-governmental organizations (NGOs) Refugees Humanitarian assistance Rules of engagement re: civilians

2. *There was no consensus among studies* (i.e., results varied widely regarding the "essential" elements of information identified; range from 20 to 62,900 essential elements).

Regarding "situational framework," Kahan, Worley, and Stasz (1989) concluded that the dimensions represented by METT-TC do, in fact, define the context of a command decision. They also argue that other elements that define the situational framework (and thus drive the commander's information needs) are the organizational structure of the command post, the commander's image or mental representation of the situation, and the interaction between the commander and his or her immediate subordinates.

Oliver & Roos (1996) suggest that scientific investigations of complex problems and environments should focus on dynamics and on the patterns and regularities that can be observed in a body of information. Further, they believe that complex systems fall into two categories: (a) *complex deterministic systems* (CDS), which are typically physical and with constant parameters, and (b) *complex adaptive systems* (CAS), which are probabilistic and include agents or sub-systems that interact, learn, and modify their behavior over time. CAS also exhibit characteristics wherein input and output are not proportional and wherein phenonema are unpredictable but are self organizing within bounds (Czerwinski, 1998). Such characteristics as nonlinearity can magnify seemingly insignificant differences in initial conditions (input states) to produce significant consequences. Long-term outcomes are essentially unpredictable but do emerge as a result of the actions (e.g., decisions) taken to influence conditions (Oliver & Roos, 1996). Van Creveld (1985), when addressing the impact of automation and technology on modern warfare, states that "...taken as a whole, present-day military forces, or all the imposing array of electronic gadgetry at their disposal, give no evidence whatsoever of being one whit more capable of dealing with the information needed for the command process than were their predecessors a century or even a millennium ago." While Van Crevald reminds us that few things change in the nature of warfare, we must also recognize that our "understandings," "images," and "mental models" of the world are undergoing rapid evolution in the Information Age as new paradigms, images, representations, and frameworks emerge.

Waldrop (1992) argues that complex systems are, in fact, characterized by many independent agents acting with each other in many ways. As a complex phenomenon, the environment of war can be expected to rapidly fluctuate between order and disorder, and the effective military command and control system should behave as a CAS rather than as a CDS. Senge (1990) further clarifies the multi-dimensionality of complex problem spaces by recognizing two classes of complexity: *detail complexity* and *dynamic complexity*. Detail complexity represents the most common understanding of

the term and includes large multivariate spaces. Dynamic complexity represents situations when cause and effect are subtle and when the effects of interventions over time are not obvious. Examples of dynamic complexity include (a) when the same action has dramatically different effects in the short run and the long run, and (b) when obvious interventions produce unintended consequences. Further, Senge suggests that the real leverage in most situations lies in understanding dynamic complexity, not detail complexity, and that we want to avoid "fighting complexity with complexity" (i.e., complex solutions to complex problems). We must begin to see relationships rather than linear cause-effect chains and to see processes rather than snapshots.

Kaufmann (1995) and Oliver & Roos (1996) offer the "fitness landscape" metaphor as a means of presenting and visualizing the many main effects and interactions that characterize a complex environment. The basic idea is that adaptive organizations will attempt to alter and improve their situation (e.g., improve knowledge of the situation) by taking "adaptive walks" to move to higher "fitness points." Failure to do so will allow competitors to outpace the organization and achieve dominance. Some key concepts associated with fitness landscapes include (Oliver & Roos, 1996):

1. *Obstacles on the Fitness Landscape*. If an organization is unable to evolve gradually, that is, the pace of change exceeds the capacity of the organization to adapt and mutate by reassembling its fundamental structures, it will face extinction. On the battlefield, this means defeat.

2. *Co-evolution on the Fitness Landscape*. Each player in a co-evolutionary struggle will attempt to improve his or her position on the landscape and will adapt to improvements by others. As each group develops a new innovation, it alters the fitness landscape of the other.

3. *Epistatic Coupling*. The fitness of any particular location on the fitness landscape is not an objective and identical value for every player. Certain higher fitness points will have more value to some players than others.

We believe that the applications of the "fitness landscape" metaphor to combat environments and to associated visualization concepts show considerable promise. This research is a first attempt to reduce the potentially large number of dimensions that influence "fitness" on the fitness landscape in combat environments and to provide a set of basic building blocks to represent salient information at any given moment in time.

OBJECTIVE

The ongoing objective of this research thrust is to better understand fundamental dimensions of battlespace complexity during the MDMP. The general thesis of the primary research effort is that the dimensions represented by METT-TC represent the essential elements of information needed by combat decision makers and that the dimensions interact in complex ways that depend on the dynamics of the battlespace environment. During this preliminary investigation, we are describing main effects of the variables only and intend to address interactions during the next phase. We were also interested to see if these dimensions would vary, based on the relative importance of the decision to be made (e.g., "major" [significant change in the currently implemented COA] versus "minor" [minor adjustment in the currently implemented COA]).

We hypothesized that the six dimensions of METT-TC can provide useful, dynamic representations of key aspects of the battlespace environment for combat decision makers and include the fundamentals necessary for DBK (Libicki & Johnson, 1996). Knowledge gained from this research program will be applied to better understand battlespace information requirements and suggest ways to better frame represent and visualize salient information at the appropriate time and place. Results are expected to substantially assist technologists and systems engineers in developing knowledge systems to assist decision makers in maintaining a current and coherent image of the battlespace.

Based on our understanding of the issues, we hypothesized that the dimensions captured by METT-TC would provide a framework from which to organize and represent the salient dimensions of the battlespace and would be of particular significance to combat decision makers during the MDMP.

APPROACH

The specific focus of this investigation was to gather preliminary data regarding the assertion that METT-TC dimensions represent important elements in the commander's decision-making process during the execution phase of ground combat. We had hypothesized that effective combat decision making would be influenced, in part, by the *perceived significance* and level of *understanding* of selected dimensions of battle-tested frameworks associated with combat environments. Further, the dimensions traditionally represented by the military acronym METT-TC would represent salient dimensions of environmental complexity and would represent important "chunks" of information framework during the MDMP. We also believed that the decision maker's reported understanding of these dimensions and their relative

significance to the decision would vary according to the types of decisions (e.g., major change versus minor adjustments).

The U.S. Army's *Crusader Concept Experimentation Program 3* (CEP 3) was presented as an ideal arena in which to conduct a preliminary investigation of selected dimensions of environmental complexity (e.g., METT-TC) and their relationship to representative battle command decisions. We were invited to collect data and information associated with the battle command staff decision-making process while observing the 3rd Brigade Combat Team (BCT), 1st Cavalry Division, during their support of the CEP3.

The objective of CEP3 was to conduct a series of soldier-in-the–loop experiments to evaluate operational concepts for the Crusader Program using a synthetic theater of war (STOW) environment developed by the Depth and Simultaneous Attack Battle Lab (D&SABL). Specific focus was on critical operational issues (COIs) related to command and control, sustainment, and system survivability. Performance data and insights are being used to prepare a document about "How to Fight the Crusader." CEP3 also supported 3rd BCT 1st Cavalry Division battle staff training of mission-essential tasks by producing realistic conditions to practice tasks on multiple occasions with a mix of staff configurations. Other battle staffs participating in CEP3 were 2-82 and 1-21 field artillery battalions. Battle staffs from the three headquarters (3BCT, 2-82, and 1-21) implemented the military planning and decision-making process, prepared and rehearsed operations, and conducted tactical engagements. During these operations, battle staffs implemented tactical orders, applied approved doctrine, and evaluated new and emerging concepts such as display and use of a nearly perfect enemy intelligence picture (from modular semi-automated force [ModSAF]). The III Corps Battle Simulation Center provided facilities, equipment, and technical support needed to establish and operate the synthetic environment. CEP3 was conducted in and surrounding Building 19032 at Fort Hood, Texas.

Environment

The 3rd BCT was situated in a field tactical operations center (TOC) configuration with organic shelters and command vehicles co-located with the III Corps Battle Simulation Center. The 3rd BCT TOC was fully populated by the command group and appropriate staff sections and personnel. The TOC command configuration changed throughout the exercise with various combinations of the commanding officer, executive officer, S-2 (intelligence), and S-3 (operations) present at any one time. The fire support officer (FSO) remained throughout the exercise. The weather was mostly clear and in the 70° to 80° Fahrenheit range with moderate humidity.

Ambient lighting and noise levels and the personnel density were normal for a field TOC. The operational tempo (OPTEMPO) was moderate with about 4 hours a day devoted to actual exercise participation.

Experimental Scenario

A tactical scenario consisting of three major events was implemented to create OPTEMPO in which issues related to the commander's courses of action (COAs) could be evaluated. Tactical engagements involved dynamic interactions between forces fighting on simulated National Training Center (NTC) terrain. Three battle runs were planned with each run consisting of three phases: (1) delay, (2) defend, and (3) attack .

Participants

Participants were five experienced field grade officers permanently assigned to the 3rd BCT. The 3rd BCT commander and his staff were representative of similar regular Army units in terms of grade distribution (e.g., E-2 to E-9 and 0-1 to 0-6) and experience. This occasion was one of about four yearly opportunities when the 3rd BCT staff trains in the field during exercise conditions. All participants were cooperative and supportive of the data collection effort.

Data Collection Instruments

Battle command decision-making data were captured using the newly developed "commander-centered decision environment inventory" (C2DEI) (Cook, 1998) and the "decision-maker self-report profile" (DMSRP) (Golden, 1998). C2DEI data are the focus of this report as they relate to salient dimensions of battlespace complexity and as associated with the combat decision-making process. Information related to decision types and decision-maker background data (e.g., rank, experience, demographics) was extracted from the DMSRP. All scenario events were in the "execution" phase of hostilities. All data were collected after completion of the scheduled events

The C2DEI was developed as a self-report instrument specifically to assess the significance of METT-TC dimensions during the MDMP. METT-TC dimensions were measured using 5-point Likert scales ranging from "1 = very low" to "5 = very high" for both "significance" and "level of understanding" of each dimension. Significance was defined as the degree to which the

dimension was important for the particular decision. Understanding was defined as the degree to which the salient aspects of the dimension were recognized and known to the decision maker.

Statistical Analysis Software

Data were analyzed using the statistical software package SPSS® for Windows™ Version 6.5 (SPSS®, 1993).

Procedures

It was expected that the brigade commander in the TOC would make a series of critical decisions over the course of each exercise scenario and that the instruments designed by our team would capture the salient factors associated with each of these decisions. Because of a very heavily committed BCT staff, we were only able to focus on one critical decision per day in the BCT and at each of the available battalions. Our team observed the evolution of each of the events and made observations as best possible without getting in the way in the typically crowded space. At the conclusion of each of the events, an after-action review (AAR) was held to assess the day's activities. At the conclusion of the AAR, we were joined by the TOC commander (CO or XO) and, when available, the S-3. A member of our team assisted each decision maker in the completion of the DMSRP and the C2DEI instruments. Completion typically took about 15 to 20 minutes per decision.

RESULTS

The primary trust of this investigation was to assess the relative "significance" and "level of understanding" of each dimension of METT-TC during a series of command decisions. During the 2-week data collection period, 24 command decisions were identified (Golden, Cook, Grynovicki, Kysor, & Leedom, 2000), and METT-TC data were collected using the C2DEI. Background, decision type, and phase of combat variables were extracted from the DMSRP. Of the 24 command decisions, 6 were considered to be "major" (i.e., a significant change in the implemented COA) and 18 were considered to be "minor" adjustments of the currently implemented COA. Of the 24 decisions made, nine were during "delay" operations, ten were during "defend" operations, and five were during "attack" operations.

For each of the dimensions represented by METT-TC, decision makers reported high levels of both "significance" and "understanding," except for "civilian considerations" which was

not represented in the experiment scenarios (see Table 2). Significant differences between the information that was needed (significance) and the information that decision makers had available were found for both Enemy and Troops dimensions.

Table 2

Descriptive Statistics for METT-TC Dimensions

Variable	Mean	SD[a]	N
Mission significance	4.30	.63	23
Mission understanding	4.39	.58	23
Enemy significance	4.39	.66	23
Enemy understanding	3.70	.93	23
Troops significance	3.75	1.07	20
Troops understanding	3.45	.94	20
Terrain significance	4.00	.79	20
Terrain understanding	3.90	.85	20
Time significance	3.96	.98	23
Time understanding	3.70	.93	23
Civilian significance	NA	NA	NA
Civilian understanding	NA	NA	NA

[a]SD = standard deviation

"Understanding" of the Mission was particularly high (M = 4.39) across decisions as was "significance" of the enemy (M = 4.39) and significance of the mission (M = 4.30). Intercorrelations among METT-TC dimensions are presented in Table 3. Of the 45 intercorrelations, six (13%) were significant ($p < .05$), suggesting a degree of dependence among several of the dimensions.

"Time available" and "troops (friendly)" considerations were more "significant" to decision makers during delay phases than during either the defense or attack phases (see Tables 4 and 5). "Terrain and weather" considerations were viewed as more significant for major change decisions than for minor adjustment decisions ($F[1,19] = 5.04$, $p < .02$).

Table 3

Intercorrelations Among METT-TC Dimensions

METT-TC dimensions	1	2	3	4	5	6	7	8	9	10	11	12
1. Mission significance	–	.65*	.47*	.42	-.41*	-.15	.00	.19	-.16	-.07	na	na
2. Mission understanding	–	–	.34	.17	-.46*	-.33	.25	-.13	.03	.06	na	na
3. Enemy significance	–	–	–	.39	.12	.14	.11	.00	-.04	.11	na	na
4. Enemy understanding	–	–	–	–	.08	.33	-.12	.38	.03	.40	na	na
5. Troops significance	–	–	–	–	–	.69*	-.06	-.03	.19	.33	na	na
6. Troops understanding	–	–	–	–	–	–	-.14	.06	-.11	.49*	na	na
7. Terrain significance	–	–	–	–	–	–	–	.62*	-.26	.14	na	na
8. Terrain understanding	–	–	–	–	–	–	–	–	-.18	.42*	na	na
9. Time significance	–	–	–	–	–	–	–	–	–	-.02	na	na
10. Time understanding	–	–	–	–	–	–	–	–	–	–	na	na
11. Civilian significance	–	–	–	–	–	–	–	–	–	–	–	–
12. Civilian understanding	–	–	–	–	–	–	–	–	–	–	–	–

Notes. (1) Only complete cases were included in the analysis; (2) na = not applicable for this scenario; (3) * $p < .05$

Table 4

"Significance" of Time According to Phase of Combat

Phase	Mean	SD	Cases
Delay	4.56	.53	9
Defend	3.78	.97	9
Attack	3.20	1.10	5
Population	4.00	.98	23

Likelihood Ratio Test = 12.9, $p < .05$

Table 5

"Significance" of **T**roops According to Phase of Combat

Phase	Mean	SD	Cases
Delay	4.44	.52	9
Defend	3.29	1.11	7
Attack	3.00	1.15	4
Population	3.75	1.07	20

Likelihood Ratio Test = 13.5, $p < .04$

CONCLUSIONS AND FUTURE DIRECTIONS

Results of this preliminary investigation support our basic hypothesis that the six dimensions of METT-TC are of considerable importance to decision makers. Further, METT-TC variables reflect the major sources of battlespace "complexity," which can be useful for organizing relationships that are changing and emerging and for knowledge necessary for decision making in near real time. It also appears that the significant dimensions of combat can be reduced to a relatively small set of variables that promise to reduce the "confusion" of combat. However, we still know little about how the many variables associated with the categories of METT-TC interact and recombine over time and how these interactions may influence the MDMP. We suggest that constructs from complexity science, complex adaptive systems theory, the ecological sciences, and systems theory offer considerable promise as an integrated framework to represent initial conditions, emergent properties, uncertainties, nonlinearities, and discontinuities commonly associated with the modern battlespace(s). Importantly, appropriate representations and presentations of the six fundamental dimensions of METT-TC should significantly support decision makers during the development and maintenance of DBK. Our findings also suggest that decision makers' "understanding" of METT-TC dimensions and associated "significance" for the decision vary according to the type of decision (i.e., major versus minor).

Specifically, our data provide initial support and validation for the basic hypothesis that the six dimensions of METT-TC represent fundamentally significant dimensions of the battlespace complexity and the command decision space. The data also validate the use of METT-TC as information and display dimensions and requirements for future command center information technology designs. Finally, the data suggest that decision makers' "understanding" of METT-TC

dimensions and associated "significance" for the decision vary according to type of decision (e.g., major versus minor).

Once the results of this investigation have been replicated in several representative military exercises, cognitive engineering and hardware-software implications for visualization and command center design will be presented. Further research is recommended to assess the internal validity and reliability of the measures and to assess the interactions and dynamics of the METT-TC dimensions across a range of combat scenarios.

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13. ABSTRACT *(Maximum 200 words)*

War is a complex phenomenon. The dynamics and complexities associated with modern military engagements, from peace keeping to major regional conflict, demand that the information associated with such environments be carefully selected, framed, and presented to facilitate effective decision making at all levels. We hypothesized that the six fundamental variables of combat represented by the military acronym METT-TC (Mission, Enemy, Troops, Terrain and weather, Time available, and Civilian considerations) would provide a framework from which to efficiently organize and represent the salient dimensions of the battlefield during the military decision-making process (MDMP). The U.S. Army's Crusader Concept Experimentation Program 3 (CEP 3) was selected as an ideal arena in which to conduct a preliminary investigation of METT-TC dimensions and their associations with representative battle command decisions. Subjects were five field grade officers permanently assigned to a U.S. Army combat unit. During a 2-week experiment period, 24 decisions were isolated and documented across three phases of combat operations (delay, defend, attack). Importantly, decision makers reported high levels of both "significance" and "understanding" for most of the dimensions represented by METT-TC, except for "civilian considerations," which were not represented in the experimental scenarios. Significant differences in levels of "understanding" according to decision types (major versus minor) were observed. In summary, experienced military decision makers recognize the importance of METT-TC dimensions, and we suggest that these dimensions offer a means to present aggregate information to increase situational understanding. Further research is recommended to isolate patterns of interactions among these important dimensions across the full spectrum of military operations.

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